# NAVAL POSTGRADUATE SCHOOL
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# THESIS

**AN ANALYSIS OF SELECTED DEPARTMENT OF DEFENSE REPROCUREMENT PROGRAMS FOR ACQUISITION OF LEGACY SYSTEM SPARE PARTS VIA SMALL MANUFACTURERS**

by

Brett E. Fillmore

December, 1997

Principal Advisor: Kenneth J. Euske
Associate Advisor: Alan W. McMasters

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# AN ANALYSIS OF SELECTED DEPARTMENT OF DEFENSE REPROCUREMENT PROGRAMS FOR ACQUISITION OF LEGACY SYSTEM SPARE PARTS VIA SMALL MANUFACTURERS

Brett E. Fillmore
Lieutenant, United States Navy
B.S., United States Naval Academy, 1991

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**December 1997**

Author: Brett E. Fillmore
Brett E. Fillmore

Approved by: Kenneth J. Euske
Kenneth J. Euske, Principle Advisor

Alan W. McMasters
Alan W. McMasters, Associate Advisor

Reuben T. Harris
Reuben T. Harris, Chairman,
Department of Systems Management

**ABSTRACT**

The life-cycle extension of weapon systems has created problems for sustaining spare parts procurement. This study analyzes selected DOD reprocurement initiatives for securing responsive manufacturing capacity of small manufacturing companies to overcome these problems. Interviews were also conducted with Government and industry representatives and managers of small manufacturing shops to identify possible barriers to the application of the DOD initiatives. The findings reveal that the DOD initiatives and their associated technologies could dramatically reduce costly lead time delays by enabling the electronic exchange of technical product data between a geographically dispersed set of qualified machine shops and DOD supply centers. However, unless DOD efforts are directed at unifying the components necessary for procuring legacy weapon system spare parts, the barriers will remain as significant obstacles.

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# I. INTRODUCTION

> Today, the U.S. has clearly the strongest military in the world. Yet, we have put off force modernization over the last decade — allowing the procurement account to fall by over 70 percent. — *Jacques S. Gansler, Under Secretary of Defense for Acquisition and Technology* (Gansler, 1997, 3)

## A. CURRENT ENVIRONMENT AND BACKGROUND

America's legacy weapon systems, those which make up today's powerful military arsenal, are experiencing a dramatic life-extension across all services. Prompted by the end of the Cold War, defense downsizing has resulted in greater priority being given to retaining and modifying legacy systems as opposed to modernization via new weapon systems (ASP, 1997). Extended service lives of existing weapon systems necessitate extension of logistics support requirements. Figure 1 depicts years of program service for selected weapon systems from the start of development to last model planned phase out.

In addition to the extension of service lives, post-Cold War downsizing also cut the volume of Department of Defense (DOD) business available for defense suppliers, creating the need for defense industry consolidation. Then-Deputy Secretary of Defense John Deutch stated in 1994 that consolidation was "inevitable and necessary" (Pitofsky, 1997, 3) to ensure survival of the defense industry.

Recognition of both life-extension and consolidation realities has increased the overall urgency with which the Department of Defense (DOD) addresses problems with the sustainment of legacy weapon systems. A paper published on

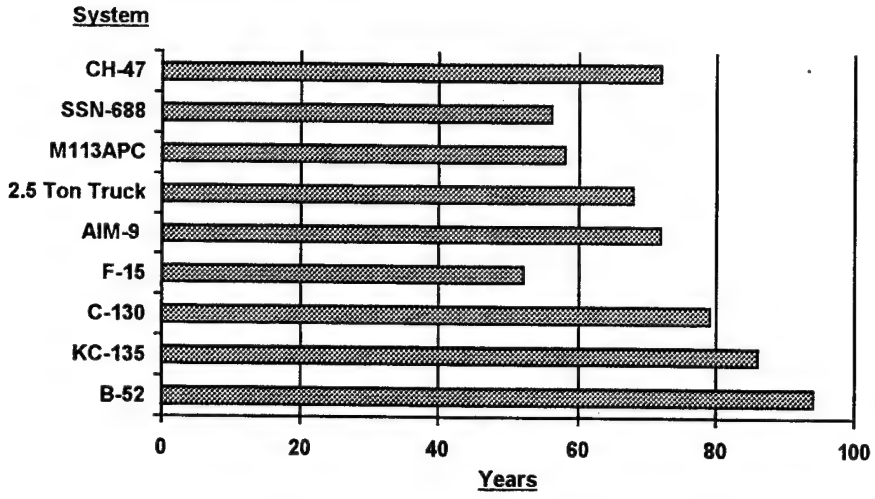


Figure 1: Examples of Service-life Extensions, Notional Program Lifetime of 30 Years (After OSD-CALS, 1997, 2.1)

19 May 1997 by the Office of the Secretary of Defense (OSD) via the Continuous Acquisition and Life-Cycle Support Office[1] (CALS) states:

> The degradation of weapon system readiness caused by the lack of parts availability is receiving increased senior DOD leadership visibility. There is ample evidence that DOD is facing a serious problem...because of the unpredictable nature of weapon system support, small purchases based on urgent need, the uniqueness of military components, dwindling sources, part obsolescence, [and] lack of drawings. (OSD-CALS, 1997, 2.2)

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[1] A memorandum dated 17 July 1997 from then-Deputy Under Secretary of Defense for Logistics John F. Phillips combined three offices including CALS into the Life-Cycle Information and Integration Office (LCIIO). Because the OSD-CALS paper was released before the creation of LCIIO, the author refers to the paper as one written by "OSD-CALS".

These and other problems increase the challenges posed by the situation in which a spare part is no longer in production and is not in stock. A Defense Logistics Agency (DLA) analysis revealed that the current timeframe for delivery of spares in this category averages "nine months" (LMI, 1997, 5). This delivery time causes America's front-line forces to suffer operational readiness degradation due to lack of needed spare parts (LMI, 1997).

## B. REALITIES OF LIFE-EXTENSION

### 1. Diminishing Manufacturing Sources

As the number of original manufacturers decline, the Department of Defense (DOD) experiences what is formally referred to as diminishing manufacturing sources (DMS). DMS refers to the extent to which 1) the defense industry has consolidated and 2) Original Equipment Manufacturers (OEMs) have ceased production or gone out of business. The Government/Industry Data Exchange Program (GIDEP)[2] collects data relevant to DMS. Figure 2 shows the increasing trend in the number of reports of discontinued parts as reported by current suppliers and OEMs. OSD-CALS reports that this trend will continue as evidenced by announcements by major suppliers that they will discontinue production of their military product lines (OSD-CALS, 1997).

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[2] GIDEP is the DOD central repository for product discontinuance notices.

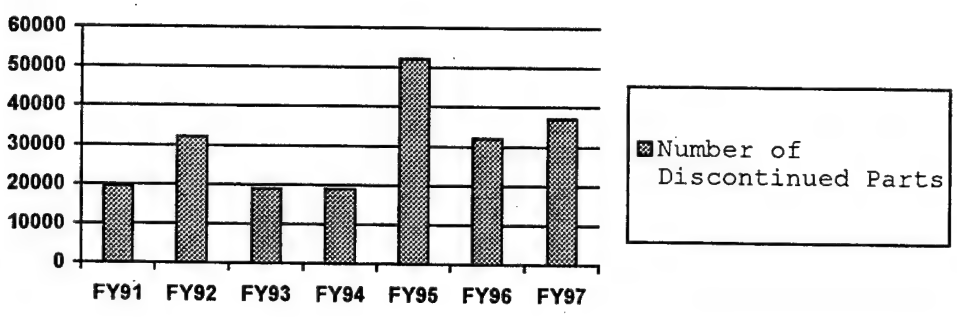


Figure 2: Number of Discontinued Parts Reported to GIDEP (After OSD-CALS, 1997, 2.2.1)

The increase in discontinued parts speaks to problems associated with the reduced availability of spare and repair parts. Examples of problems that the Department of Defense (DOD) encounters are listed below:

- Original Equipment Manufacturers (OEMs) plan to cease production of spares according to the planned-for end of useful life. Decisions to extend a weapon system's service life therefore result in the unavailability of certain spare parts; (OSD-CALS, 1997; ASP, 1997)

- Manufacturing or maintenance skills are lost, requiring an extensive search for the needed capability. Such concerns surfaced during deliberations on the teaming arrangement between Electric Boat and Newport News Shipyard, which preserves submarine construction capacity at more than one facility; (Honeker, 1997)

- The Department of Defense (DOD), with a decreasing market share in the post-Cold War era, is no longer in a position to dictate market trends and/or force supplier compliance with DOD wishes; (Ryburn, 1997)

- Diminishing Manufacturing Sources (DMS) increase the likelihood that Technical Data Packages (TDP) are unavailable, incomplete, or inaccurate, restricting timely and accurate remanufacture because of delays in precisely defining the physical details of the part. (OSD-CALS, 1997)

### 2. Part-related Problems

Extended system lifetimes mean not only warfighter reliance on older weapon systems, but also an extension of the spare parts requirements of those systems. Problems linked to the actual parts which result from unplanned life-extension are described below:

- The high rate of technology change promotes materiel obsolescence sooner; (Grisar-B, 1997)
- Some weapon system components are not designed for replacement within the expected lifetime, therefore no spare part demand was anticipated; (OSD-CALS, 1997; ASP, 1997)
- Older parts are inherently more likely to experience failure, which puts front-line personnel at imminent risk; (OSD-CALS, 1997)
- Tooling designed for high-volume initial production is not cost-effective for low-volume replacement parts production, or tooling no longer exists. (ASP, 1997)

## C. PURPOSE

This thesis addresses U.S. Government efforts to solve the some of the spare parts problems by enabling digital technical data exchange with Small- and Medium-sized Enterprises (SMEs). This statement covers an extensive number of topics. Therefore, it is important to define the scope of the thesis.

## D. SCOPE

### 1. Defining the Spare Parts Type

To limit discussion to a portion of the many kinds of manufactured parts, the thesis focuses on Small Mechanical Parts (SMPs). Generally, these parts are classified as those can be machined from a solid piece of material, and that fit into standard CNC (Computer Numerical Control) milling machines and/or lathes. This restriction limits parts to a size of roughly two cubic feet or less. Coverage only of Small Mechanical Parts (SMPs) eliminates discussion of such processes as metal casting, forging, sheet metal fabricating, and heat treating. Also, microelectronics parts such as circuit boards are not considered in this study.

### 2. Demand Characteristics

As suggested by the brief discussion above of legacy weapon systems, demand for Small Mechanical Parts (SMPs) is unpredictable and is often associated with urgent operational requirements. The parts considered in this study are typically out of stock, out of production, and commercially unavailable. Their production requires *remanufacturing* – the design and creation of a new product from raw materials. The process might also include a *reverse engineering* effort, whereby a damaged or dysfunctional part must be remeasured in order to obtain the exact specifications. Technologies which assist in these costly and time consuming processes are described in Chapter III.

A consideration not explicitly discussed in this thesis is the notion of purchasing Technical Data Packages (TDPs) as part of the procurement contract, or during the system life-cycle. One study which discusses digital Technical Data Package (TDP) ownership throughout the life-cycle is Honeker's study of the NSSN, or New Attack Submarine (Honeker, 1997).

### 3. Small- and Medium-sized Enterprises (SMEs)

In this study, Small- and Medium-sized Enterprises (SMEs) refer only to makers of Small Mechanical Parts (SMPs). A firm is generally classified "small- or medium-sized" when it has 500 or fewer employees (ECRC, 1997). These enterprises can be divided into two pools.[3]

#### *a. Electronically Capable Enterprises*

The first pool of enterprises discussed in this thesis have some capability of conducting business and manufacturing processes electronically. These manufacturing firms communicate with clients using the Internet, e-mail, and fax machines. They have a number of CNC machines and employ CAD/CAM, Computer-Aided Design/Computer-Aided Manufacturing, technology in machining their products. This pool is central to the focus of the thesis.

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[3] Unless otherwise specified, the thesis always addresses one or both pools of "SME", as defined by the scope of the paper.

### *b. "Manual" Enterprises*

The second pool might have some of the technology assets described above, but they rely less on such technology for both business and manufacturing uses. While these shops might not be as capable of solving the near-term problems of getting spare parts to the warfighter, there is a Government effort to bring this pool of manufacturers up to speed in doing business electronically. Electronic Commerce Resource Centers (ECRCs) are one just one example of Government-sponsored outreach which this thesis addresses (ECRC, 1997).

## 4. Willingness

The thesis also addresses the willingness of Small- and Medium-sized Enterprises (SMEs) to participate as a supplier of U.S. military spare parts. The term "willingness" primarily refers to technological, economic, and contracting barriers which impede a manufacturer's ability to supply the Department of Defense (DOD). Willingness has less to do with choice than with possibility.

## 5. Multiple Sources of Government Outreach

This thesis includes discussion of efforts by other Government-sponsored organizations including the Department of Energy (DOE), the Defense Advanced Research Projects Agency (DARPA), the National Institute of Standards and Technology (NIST), as well as state, university, and regional entities to involve small enterprises in processes which could result in expansion of the military supply chain. Although these organizations participate in various

aspects of science, research, and education, this thesis focuses on promotion of technical data exchange by small enterprises as a mechanism for reprocurement of spares by DOD. Specific outreach organizations and their efforts are discussed in Chapter III.

### 6. Timeframe for the Study

Although the technology exists today that provides possible answers to general legacy spare parts problems, complete answers to remanufacturing and reverse engineering challenges should not be expected to occur overnight. Most programs considered in this thesis are at early stages of development or implementation. Several barriers to DOD's successful use of SMEs and digital data are presented in Chapter IV.

## E. METHODOLOGY

The author studied the capabilities of Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM) to attain a working knowledge of the mechanisms used to manufacture Small Mechanical Parts (SMPs). The author also learned about the outreach programs and technologies, to be discussed below, from the Internet, brochures, and annual reports. This process gave the author a sense of what was technologically possible in procurement of spare parts.

A sense of the magnitude of logistics issues confronting DOD was obtained by attending the "21st Century Commerce and CALS Expo '97". Here, the author gained an appreciation for the broad issues concerning legacy weapon system spares. The author met Government and industry

representatives whose work is congruent with this thesis. These meetings resulted in the author receiving several project reports which provided additional insight and empirical data.

Finally, e-mail exchanges and telephone interviews were conducted to learn specific information about the problems confronting Government and small businesses in the field of flexible, computer-integrated manufacturing (FCIM)[4]. There were more than 90 hours of interviews with nine managers of small manufacturing firms as well as 16 Government and industry officials.

## F. ORGANIZATION OF THE STUDY

This thesis looks at a set of initiatives that are intended to match Technical Data Interchange (TDI) technologies with the responsiveness of SMEs. Each initiative concentrates on some aspect of uniting SMEs with the DOD's demand for spare parts required by legacy weapon systems. Within that context, the thesis describes each initiative or technology, and discusses some possible barriers that affect small manufacturers' willingness to serve as a DOD supplier. With the participation of "geographically dispersed and electronically integrated" SMEs (ODM Workshop, 1996), DOD initiatives can reduce lead times and costs of small lot, low demand machined parts.

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[4] A term coined by DOD, FCIM is "the integration of equipment, software, communication, human resources, and business practices within an enterprise to rapidly manufacture, repair, and deliver items on demand, with continuing improvement to the processes." (Gentsch, et. al., 1996, 1-3)

The ensuing two chapters are arranged to develop a top-down look at Government initiatives. For each initiative, the author describes its effort in promoting collaboration — whether through technology, policy, or personal interaction.

Chapter II presents the broadest picture; namely, the overarching initiatives rooted within the Office of the Secretary of Defense (OSD). The chapter describes two specific programs and points out the importance of small manufacturers in those programs' success. These programs seek the skills possessed by the electronically capable pool of manufacturers.

Chapter III consists of two parts. Part One demonstrates regional efforts to modernize and unify the capabilities of small manufacturers through adoption of computer-integrated manufacturing (CIM) technologies. The efforts depend on the spread of Electronic Commerce (EC), Electronic Data Interchange (EDI) and the development of technological proficiency at the SMEs' level. Part Two of Chapter III explains some technological improvements to the existing digital data exchange methods in use between Government buyers and small manufacturing suppliers.

Chapter IV addresses some issues which inhibit the initiatives of Chapter II and the use of digital product data by DOD and small manufacturers. Also, it discusses manufacturers' willingness to participate as a DOD supplier. In Chapter IV, an appreciation for the challenges facing DOD becomes apparent. Input from logistics experts, program sponsors, consortia members, outreach facilitators, and small business owners help define a set of possible barriers which could prevent small firms from supporting DOD's efforts to procure legacy system spare parts.

Chapter V presents an analysis of the implementation issues and suggests areas for future study in this relatively new and complex field. Chapter VI provides a thesis summary, conclusions, and recommendations.

## II. TWO GOVERNMENT INITIATIVES: ON-DEMAND MANUFACTURING (ODM) AND THE VIRTUAL PARTS SUPPLY BASE (VPSB)

Two broad initiatives are the subject of this chapter: the Defense Logistics Agency-sponsored On-Demand Manufacturing (ODM) initiative and the Continuous Acquisition and Life-Cycle Support Office (CALS) initiative, the Virtual Parts Supply Base (VPSB). Before embarking on a discussion of each of these programs, this chapter provides evidence that the Department of Defense (DOD) is committed to processes that incorporate technical data interchange throughout a weapon system's life-cycle. The chapter concludes by highlighting differences in the programs and by showing that Small- and Medium-sized Enterprises (SMEs) are necessary for the success of these initiatives.

### A. OFFICE OF THE SECRETARY OF DEFENSE (OSD) LEADERSHIP

On 2 July 1997, then-Deputy Secretary of Defense John White established the Digital Program Office. This event triggered a series of documents which collectively draw attention to DOD's recognition of the importance and potential benefits of digital data exchange. Secretary White stated:

> It is now time to move forward to a fully digital environment in all acquisition program and support offices. I am setting a corporate goal of digital operations being the method of choice for all acquisition management and lifecycle support information. By the end of 2002, the overwhelming majority of DOD acquisition and logistics operations should be based on digital methodologies and products. (White, 1997)

The establishment of the Life-Cycle Information Integration Office (LCIIO) by the Deputy Under Secretary of Defense for Logistics (DUSD(L)) is one action prompted by White's corporate goal. The LCIIO has the following goal:

> [E]stablish an environment that allows every activity involved with a program throughout its life-cycle to benefit from integrated information, and electronic data interchange. (Phillips, 1997)

The Department of Defense (DOD) and other Government entities are pursuing answers to the legacy spares problem in accordance with this guidance. The Assistant Deputy Under Secretary of Defense for CALS and Director of the LCIIO, Mr. Mark Adams, addressed an audience of defense industry leaders with these collaboration-inducing questions:

- What are the factors that limit broad proliferation of [information technology] across the life-cycle?
- How can we more rapidly apply information technology to improve Operations and Maintenance (O&M) costs, given that they comprise 60 percent of life-cycle cost?
- What are the key top-management actions in DOD that are required to accelerate [information technology] development and implementation? (Adams, 1997)

These questions demonstrate Adams' desire to embark on a new era for the relationship between private industry and DOD.

## B. ON-DEMAND MANUFACTURING (ODM)

### 1. Strategic Intent

A 1997 Functional Economic Analysis (FEA) of the On-Demand Manufacturing Program defined ODM as one which could "improve the supply of spare and replacement parts." (Gentsch, 1997, iii). One subset of supply parts targeted by ODM is the "low volume and sporadic need items...that must be manufactured to order." (LMI, 1997, 4) ODM arranges for pre-established, qualified suppliers so that DLA can "buy parts when they are ordered by customers, rather than stocking them in anticipation of a demand." (Gentsch, 1997, 2-2) Thus, On-Demand Manufacturing (ODM) seeks to satisfy some of the spare parts problems caused by legacy weapon system life-extension.

### 2. On-Demand Manufacturing's Focus

ODM focuses on making wholesale improvements to the current system of spare parts reprocurement. The improvements target the two components of overall lead time. Both administrative lead time (ALT) and production lead time (PLT) are to be reduced. The Functional Economic Analysis (FEA) states, "By performing certain administrative and production planning tasks in advance of a customer's demand, the time the customer waits for his part can be minimized." (Gentsch, 1997, 2-2)

The following sections break down the two categories of lead time (ALT and PLT) to demonstrate the specific delays which On-Demand Manufacturing (ODM) intends to minimize.

### *a. Administrative Lead Time*

ALT is defined as the time "between a purchase request and award of a contract or delivery order." (Gentsch, 1997, 4-1) ALT consists of:

- Requirements Generation – user places order with service Inventory Control Point (ICP);
- Management Review – determine if part is available, consider and determine remanufacture options, gain funding approval;
- Technical Review – assembly of technical data to support the procurement;
- Procurement – solicit bids, await contractor response to bids, source selection, and award the contract;
- Other Review – any referrals to other functional areas for additional processing (internal or external to the ICP). (Gentsch, 1997)

Results of the Functional Economic Analysis (FEA), shown in Figure 3, reveal the distribution of these ALT categories.

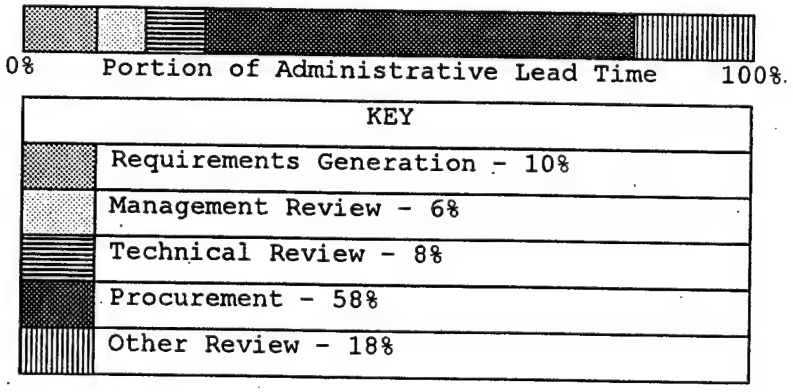


Figure 3: Breakdown of Administrative Lead Time (After Gentsch, 1997, 4-1)

The crux of cutting ALT lies in "decoupling the source-selection and contracting process from the actual requirement to order a manufactured part" (Gentsch, 1997, 4-1), completing as much of the above processes before demand arises as possible.

### *b. Production Lead Time*

Contract award is the milestone which marks the transition between ALT and PLT, since "production lead time is the time between contract award...and the first significant delivery of parts." (Gentsch, 1997, 4-2) Production lead time (PLT) consists of:

- Order Processing – administrative efforts related to getting the contract underway and entering the job into Government accounting system;
- Materiel Acquisition – find sources, order raw materials;
- Scheduling/Production – includes wait for machines to become available, manufacture;
- Testing/Shipping – conduct tests and ship part to user. (Gentsch, 1997)

The LMI breakdown is depicted in Figure 4.

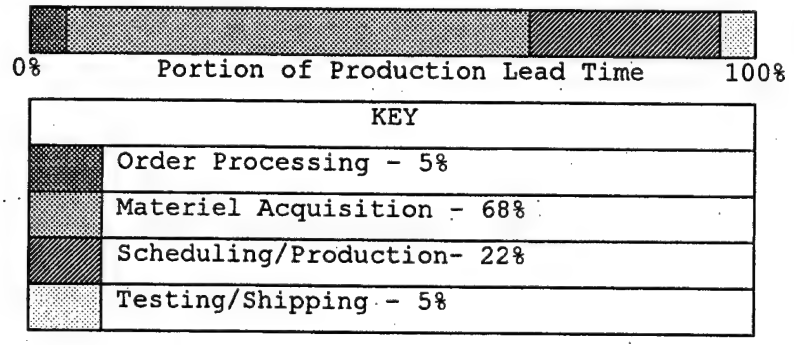


Figure 4: Breakdown of Production Lead Time (After Gentsch, 1997, 4-2)

## 3. Solutions via On-Demand Manufacturing

ODM proposes to slash administrative lead time (ALT) by pre-certifying its contractors, establishing long-term contracts with those contractors, and having electronic validation processes in place to support rapid Technical Data Package (TDP) certification and review. (LMI, 1997)

Reductions in production lead time (PLT) result from enabling contractors to plan for work on a known set of parts and, therefore, a known set of raw materials. This plan enables suppliers to purchase raw materials ahead of demand. This is made possible by DOD supply organizations' grouping of National Stock Numbers (NSNs), which is explained below.

### a. *Families of Parts*

On-Demand Manufacturing (ODM) proposes a system which capitalizes on the advantages gained by grouping needed parts into families with similar characteristics. The Model Contract for On-Demand Manufacturing (MCODM) explains:

> A key feature of the contract is the Contractor's capability to deliver non-specified goods that share material, design, or process characteristics with the specified goods...." (LMI, 1997, 6)

Under contract for a known family of parts, a supplier can anticipate material requirements in advance of the Government's order. This enables them to handle material acquisition and production scheduling more effectively.

Also, part grouping enables the award of a larger-volume contract. Instead of making five of one item for one contract on one occasion, the contractor gets to fulfill contracts as demand occurs for a variety of similar parts. This prospect is attractive to suppliers, who experience seasonal demand peaks and valleys according to the Government's fiscal year. Says one manufacturer,

> There is a definite cycle [where DOD] funds run out at the end of September; ODM would give a stable base, smoothing out workload. [F]rom that standpoint I find [On-Demand Manufacturing] attractive. (Parks, 1997)

### *b. Contractor Pre-Selection*

Grouping of parts into families could facilitate pre-selection of contractors according to their specific capabilities to make these parts. The establishment of a contract with one or more suppliers ahead of time would avoid many time-consuming delays in the procurement component of administrative lead time (ALT). ODM is based on the premise that an urgent demand for parts requiring remanufacture could more often be quickly satisfied if source selection and contracting had been completed. (Gentsch, 1997; LMI, 1997)

### *c. Contract Features*

The Model Contract for On-Demand Manufacturing (MCODM) proposes a technique whereby the Defense Logistics Agency (DLA) commits to purchase a given portion of a contractor's manufacturing capacity each month (Gentsch, 1997). This portion would be measured in dollars for goods and services anticipated to be needed, rather than

reservations of a number of machines, percentage of floor space, workdays per month, etc. The contract would propose a monthly payment equal to at least a pre-determined minimum but not more than a pre-determined maximum. Under MCODM,

> DLA is not required to order any particular parts or specified quantity thereof. Rather, this arrangement is for the capacity to make parts as well as for the actual manufacture of parts that may be ordered. (LMI, 1997, 6)

Historically, each remanufacture contract with a private firm has been handled separately and has required a complete acquisition and production cycle (Gentsch, 1997). MCODM would solidify supplier capacity for "three years or more, with possible options to extend." (Gentsch, 1997, 7-2)

Since the program aspires to facilitate rapid delivery, MCODM makes provisions for accelerated or delinquent delivery by contractors. An Expedited Delivery Premium may be charged to DLA provided the ordering activity accepts the added requirement for early delivery. While a firm rate is not presently established, the early delivery premium will equal x percent of the nominal price per day. Similarly, a Delayed Delivery Penalty may be appropriate if a supplier fails to deliver some or all of an order by the prescribed date on the contract. (LMI, 1997)

MCODM is attractive to engineers and technicians who do not care for the battles waged in contract negotiations. One manufacturer remarked, "I'm not a marketeer, [and] don't enjoy [haggling] over contracts. Just give me the work and I'll do the work." (Parks, 1997)

DLA could use the Model Contract for On-Demand Manufacturing (MCODM) for nearly all categories of reprocurement and resolve many current issues associated

with infrequent demand. However, On-Demand Manufacturing (ODM) assumes the presence of some form of technical data (Gentsch, 1997; Ryburn, 1997). There remain resupply challenges in which some aspects of the supply system are non-existent (e.g., no raw material as specified in the technical drawings). The following initiative, the Virtual Parts Supply Base (VPSB), intends to satisfy those challenges by utilizing existing sources pooled into a virtual enterprise (OSD-CALS, 1997).

## C. THE VIRTUAL PARTS SUPPLY BASE (VPSB)

> The objective of the VPSB project is to improve the sustainability of DOD weapon systems. The improvement will be accomplished by augmenting the existing supply system with a new methodology that integrates existing resources into a virtual enterprise. (OSD-CALS, 1997, 1.0)

This quote, taken from the Virtual Parts Supply Base (VPSB) Concept Paper (OSD-CALS, 1997), captures the essence of the initiative. The following sections provide an explanation of VPSB organized according to key terms from the above citation.

### 1. New Methodology...Virtual Enterprise

VPSB's methodology relies on extensive technical data interchange and participant collaboration. Collaboration is a trademark of virtual organizations, which tend to operate seamlessly, free of boundaries, and independent of location. VPSB will include public and private sector manufacturers in providing engineering resources and manufacturing capabilities for the reprocurement of problem parts. (OSD-CALS, 1997)

The VPSB Concept Paper defines a virtual enterprise as follows:

> A virtual enterprise is a highly flexible business venture based on the dynamic collaboration of diverse groups using electronic communications to increase productivity and responsiveness and operate with greater agility. (OSD-CALS, 1997, 1.1)

This dynamic collaboration involves the entire solution set of VPSB participants, which include Government assets, industry assets, and reverse engineering entities.

### 2. Sustainability

The VPSB Concept Paper's introduction addresses concern about weapon system life-extension. The Virtual Parts Supply Base (VPSB) recognizes the length of these extensions and could eventually satisfy more than the near-term spare parts demand. The virtual enterprise's output includes an accurate and transferable Technical Data Package (TDP) for the part. Following completion of the initial order, the virtual enterprise transfers custody of the TDP to the appropriate service organization, such as an Inventory Control Point (ICP), where it can be used in future procurements.

### 3. Augmentation

The Virtual Parts Supply Base (VPSB) is not designed to be a repetitive manufacturing entity that competes with industry. Instead, the virtual enterprise established for "Part A" disbands at the completion of the job. One industry official explains,

> VPSB redesigns, reverse engineers, builds, validates the TDP, conducts testing, and ships the part. Then it disbands and gets out of the manufacturing business. (Grisar-B, 1997)

Firms within the "Part A" virtual enterprise are eligible to compete for future procurements of "Part A". As discussed above, future procurements would make use of the technical data created by the previous effort.

The OSD-CALS Office sees VPSB as *the overarching program* for the reprocurement of problem parts which are causing work stoppages at the military services' repair depots. According to the VPSB Concept Paper:

> ...over the years a number of organizational activities have evolved to address specific logistic support problems. Although successful in their own right, what has been missing is a logical, established process of integration, interface, focus, and a management decision mechanism to employ these various elements. Therein lies the genesis of VPSB. (OSD-CALS, 1997, 5.2)

## D. OSD-CALS AND DLA PHILOSOPHICAL DIFFERENCES

OSD-CALS and DLA agree that grouping of National Stock Numbers (NSNs) and manufacturer pre-selection are excellent means of not only shortening lead times, but also of improving the cost and quality of parts. OSD-CALS looks to capture the efforts of On-Demand Manufacturing (ODM) under its umbrella of functions, although one ODM tenet remains the subject of debate. (Ryburn, 1997)

The Defense Logistics Agency (DLA) sees advantages in buying "responsiveness instead of inventory" and of committing to a regular and consistent consumption of capacity (OSD-CALS, 1997, 3.2). Opposition to this

committment tactic stems from concern that it unnecessarily pays for manufacturing capacity up-front.

It is important to note that the initiatives (ODM and VPSB) have different implementation timeframes regarding Small Mechanical Parts (SMPs). On-Demand Manufacturing is the more mature program. If the Defense Logistics Agency (DLA) could rely on virtual enterprises, it could possibly avoid paying for responsiveness ahead of demand. But without extensive electronic networking of manufacturing firms, DLA must "act like a predictable customer" in order to assure capacity (Gentsch-A, 1997). For now, that means funding capacity ahead of demand.

## E. USE OF SMALL FIRMS TO SOLVE REPROCUREMENT PROBLEMS

This chapter has presented two DOD-sponsored programs which are intended to cut lead times, enable the rapid remanufacture of needed spare parts, and bolster readiness. Each program proposes improvements to the spare parts procurement process by entering into collaborative arrangements. Each provides a market for the manufacturing talent of Small- and Medium-sized Enterprises (SMEs) armed with the responsiveness necessary to manufacture small lot-size spares on-demand.

Proof of a smaller-sized firm's edge in responsiveness was illustrated by one industry official. He remarked that large organizations tend to have large decision-making hierarchies which prevent decisions from being made near the front line. As an example, he said he had been waiting over two months for a quote from a large firm. His point was that the decision-makers at smaller shops are typically closer to the front line, thereby cutting time spent in

deliberation about quote pricing and project timelines. (Bradham, 1997)

According to Under Secretary Gansler,

> Additional steps are required for the government to encourage firms that are not currently defense suppliers — and yet are world-class in their areas of specialization — to become players in the defense world, at either the prime or lower tiers. (Gansler, 1997, 7)

The organizations discussed in the next chapter are working to implement Secretary Gansler's request. They are trying to bring SMEs into the Department of Defense (DOD) supply base and utilize modern information technologies.

# III. CATALYSTS FOR IMPLEMENTATION OF REPROCUREMENT INITIATIVES

The Virtual Parts Supply Base (VPSB) and On-Demand Manufacturing (ODM) initiatives require firms that have the capability *today* to compete for bids electronically and supply unique, low-volume replacement parts. Yet, there is unused potential capacity housed in machine shops that have not adopted modern manufacturing and business tools. Technologies such as CNC (Computer Numerical Control) machines, Electronic Data Interchange (EDI), Electronic Commerce (EC), and Technical Data Interchange (TDI) are vital to increasing the size and talent of the available supplier pool. (ECRC, 1997)

The topic of this chapter is outreach to both "electronically capable" and "manual" small manufacturers mentioned in Chapter I. The chapter is divided into two parts; Part One deals with a sample of hands-on outreach programs which educate small manufacturers, and Part Two discusses information technologies. Each topic represents an effort sponsored, either partially or totally, by Government organizations.

## A. PART ONE: EDUCATION AND NETWORKING OUTREACH

The following three organizations each works to develop capabilities of small manufacturers in some aspect of flexible manufacturing. They are Electronic Commerce Resource Centers (ECRCs), the Oak Ridge Centers for Manufacturing Technology (ORCMT), and the Robert C. Byrd Institute (RCBI).

### 1. Electronic Commerce Resource Centers (ECRCs)

One might ask what flexible manufacturing has to do with Electronic Commerce (EC), defined as,

> ...the conduct of business transactions (including the supporting functions of administration, finance, logistics, procurement, and transportation) between...DOD and private industry, using an integrated automated information environment. (PTA, 1997, 14-25)

The answer lies within the scope of work in these areas performed by Electronic Commerce Resource Centers (ECRCs). Then-Deputy Under Secretary of Defense for Logistics John F. Phillips connected EC with DOD supply needs in the following statement:

> The ECRC Program focuses on...smaller businesses to help them understand and use electronic commerce, and to keep pace with rapidly evolving technologies and plan for the future. With this focus, the ECRC Program helps the entire DOD supply chain. (ECRC, 1997, 1)

Mr. Phillips' statement that the DOD supply chain is helped if smaller businesses "keep pace" and "plan for the future" indicates that ECRCs are closely linked with a Defense Department agenda. Funded by the Department of Defense, sponsored by the Deputy Under Secretary of Defense for Logistics (DUSD(L)), and under the operational control of the Defense Logistics Agency (DLA), ECRCs reach out to small businesses to encourage their involvement with an increasingly technical military supply system. (ECRC, 1997)

ECRCs perform a significant portion of their educational role by hosting free seminars at sixteen Regional ECRCs for any business that supply the Government.

The principal fundamental taught by ECRC facilitators is Electronic Data Interchange (EDI), defined as,

> ...a form of electronic communication that allows...one or more organizations to exchange business data in structured formats that can be processed by application software [and can enhance] the productivity and effective use of timely and accurate business information. (Serguson, 1993, 7)

ECRCs teach "manual" enterprises the value of performing business functions electronically; but, ECRCs go beyond "teaching people how to spell E-D-I." (Grisar-B, 1997) Table 1 shows a partial listing of ECRC seminars.

| | |
|---|---|
| Electronic Commerce Hardware and Software Requirements | Getting Started with Electronic Commerce |
| Technical Data Interchange | EDI Orientation |
| Issues in EDI Implementation | Business Opportunities with the DOD Through EDI |
| Recovering Design Data | Legacy Data Management |

Table 1: Examples of Electronic Commerce Resource Center (ECRC) Seminars (After ECRC, 1997, 7)

The ECRCs' efforts ultimately encourage participation by small manufacturers in the supply of low-cost, high-quality goods and services. ECRCs are a key resource in extending initiatives that could assure that critical replacement parts will be available for aging weapon systems well into the 21st century. (ECRC, 1997)

### 2. Oak Ridge Centers for Manufacturing Technology

Unlike Electronic Commerce Resource Centers (ECRCs) which essentially have no mechanical production capacity, other outreach programs operate with the support of

significant technological assets. For example, the Oak Ridge National Laboratory (ORNL) is a Department of Energy (DOE) facility operated by Lockheed Martin Energy Systems (LMES) in Oak Ridge, Tennessee. Emphasis is placed on energy issues, but the laboratory also supports a myriad of other technologies. (Douglass, 1997)

The Department of Energy recently broadened the mission of ORNL's Y-12 Plant[5] to include active sharing of unclassified, non-sensitive manufacturing technology with the private sector. This new mission resulted in the Oak Ridge Centers for Manufacturing Technology (ORCMT), a collaboration of the "National Laboratory" and the Y-12 Plant, that encompasses both facility-lending and training programs. (Douglass, 1997)

#### *a. ORCMT Outreach*

One of ORCMT's many programs utilizes a previously-established network to assist its outreach efforts. The network hub is the University of Tennessee's Center for Industrial Services (CIS). CIS holds the contract in Tennessee for two Government-sponsored outreach programs:

- Manufacturing Extension Partnerships — sponsored by the National Institute of Science and Technology (NIST); state-level university-sponsored educational outreach (Klein, 1997)

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[5] Oak Ridge National Laboratory's Y-12 Plant is a world leader in precision manufacturing and quality control. It served as the manufacturing hub for U.S. nuclear weapons components and provides key components for the SEAWOLF submarine program.

- Procurement Technical Assistance centers – sponsored by Department of Defense; supplements electronic billboards such as Commerce Business Daily and gives notice of DOD contract opportunities (e.g. spare parts reprocurement contracts) (Douglass, 1997).

#### *b. ORCMT-CIS Teamwork*

ORCMT looks to supplement CIS's outreach efforts by offering technical assets which support a Government-certified small manufacturer in making a complex spare part. For example, a challenging reverse engineering effort may require the expertise and equipment of Oak Ridge's Y-12 Plant; without ORNL assets, the reverse engineering would not be possible. The overall partnership between CIS and ORCMT gives participants access to essentially unsurpassed technological leverage. (Douglass, 1997; ORNL, 1997)

### 3. The Robert C. Byrd Institute (RCBI)

Funded through a Congressional grant and sponsored by the Defense Advanced Projects Research Agency (DARPA), the Robert C. Byrd Institute (RCBI) helps West Virginia's small metalworking manufacturers attain a standard of quality suitable for Department of Defense (DOD) supplier status. Located in Huntington, West Virginia, RCBI conducts hands-on training, leadership forums, and technology outreach with SMEs. (RCBI, 1997)

#### *a. Technical Services*

The Technical Services Unit trains workers on CNC (Computer Numerical Control) machines and creates the opportunity to see the benefits of advanced manufacturing technology. The RCBI facility has CNC machines available for

lease by small machine shops, whose workers bring raw materials and soft tooling (e.g. drill bits) to RCBI. (Lindsey, 1997)

The Institute uses a costing system whereby lessees pay as though the CNC machine was located in their shop. RCBI's Chief Technology Officer explained that,

> [We] give them a reasonable idea of what it would cost to have the [CNC] machine in their shop...because we want them to adopt the technology. (Lindsey, 1997)

RCBI is establishing two additional Technical Services Units[6], providing greater coverage of West Virginia and enabling machine shops from around the state to realize the benefits of using CNC machinery (Lindsey, 1997).

### *b. Systems Modernization*

RCBI works to improve the business communications systems of its satellite firms. Electronic Data Interchange (EDI) facilitation and Internet-based information transfer systems provide firms with a network not only among themselves, but also to commerce available on the Internet. (RCBI, 1997)

### *c. 21st Century Manufacturing Project*

RCBI recognizes the challenges facing small enterprises as they strive to survive within increasingly competitive markets. Greater technological sophistication and higher standards of quality put small manufacturers at

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[6] The units will be in Rocket Center, West Virginia and Charleston, West Virginia. (Lindsey, 1997)

risk (RCBI, 1997). As discussed in Chapter I, forces such as defense industry consolidation and a shrinking defense market make RCBI's mission even more challenging.

RCBI's 21st Century Manufacturing Project enables firms to pool their capabilities and compete in markets which they otherwise could not. RCBI fosters a shared information environment, providing clients with contracting information and assistance that enables its firms to do business with DOD. RCBI acts as a catalyst to organize groups of firms into networks to assist in identifying new business opportunities in commercial and DOD markets. (RCBI, 1997; Lindsey, 1997)

## B. PART TWO: TECHNOLOGICAL TOOLS

The first of three technologically focused programs that provide support to the DOD vision of a network of small suppliers is the Rapid Acquisition of Manufactured Parts (RAMP) program.

### 1. Rapid Acquisition of Manufactured Parts (RAMP)

The South Carolina Research Authority (SCRA) is a non-profit scientific and engineering organization established in 1983. In one of its most successful ventures, SCRA heads a consortium[7] which serves as the prime contractor for a Department of Defense-sponsored program called RAMP, the Rapid Acquisition of Manufactured Parts. (SCRA, 1996)

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[7] The consortium consists of Grumman Data Systems, Arthur D. Little, Battelle, Day and Zimmerman Services, and SCRA.

> RAMP...is a research and development project designed to provide the capabilities for "on demand" manufacture of non-standard parts required for national defense and industrial applications. (SCRA, 1996, 12)

RAMP was created to "develop and prototype the capability for data driven, just-in-time, low-volume manufacturing of hard to obtain items" on behalf of the Naval Supply Systems Command (NAVSUP). (SCRA, 1996, 13) The following statement summarizes the RAMP Team's focus on helping small manufacturers attract business:

> ...[T]he RAMP Team's efforts...make RAMP technology more readily adaptable to the small and medium-sized manufacturers who supply the vast majority of parts for U.S. defense. (SCRA, 1996, 15)

RAMP's technologies have evolved to the extent that they are keeping pace with the information revolution of the 1990s. The "RAMP Team" followed through on suggestions listed in SCRA's 1996 Annual Report:

> The Team is keenly attuned to today's hardware and software market in which PC-based products are now available that offer capabilities that in RAMP's earlier years could only be provided by powerful workstations and expensive software packages. These new products are enabling the RAMP Team to redesign and repackage many of RAMP's capabilities, tailoring them to the needs of those smaller manufacturers. In addition, considerable effort is being devoted to providing RAMP with a full complement of Electronic Data Interchange functions that will allow RAMP-capable sites to conduct electronic commerce with both government and industrial organizations in a "virtual" business environment. (SCRA, 1996, 15)

This kind of approach toward outreach parallels those of the Virtual Parts Supply Base (VPSB). The next technology is a product of RAMP technology which could help identify suppliers for VPSB and On-Demand Manufacturing (ODM).

### 2. Group Technology Selection System (GTSS)

The RAMP Team has developed a technology which revolutionizes the means through which buyers solicit suppliers. (RAMP, 1997). The new system, the Group Technology Selection System (GTSS), provides a database about both specific supplier capabilities and physical traits of National Stock Numbers (NSNs). Use of the database informs buyers which suppliers are capable of making a given part. This can prevent distribution of wasteful solicitations to unqualified contractors.

With GTSS, each NSN can be digitally coded and

> ...queried by its legacy drawing number/part number, item type, plating, treatment, coating, material specification, material name, special processes, or industry material type. (GTSS Report, 6 August 1997, 4)

Similarly, GTSS stores categories related to identification and capabilities of suppliers (vendors). The following quotation is from the GTSS Report:

> The Group Technology Selection System (GTSS) is a Personnel Computer (PC) based production application developed by Team SCRA (South Carolina Research Authority) to assist Defense Logistics Agency (DLA) procurement to effectively perform the following:
>
> - Identify qualified vendor(s) for a given National Stock Number (NSN) or a group of NSNs;

- Identify and group NSNs by a specified set of parameters or feature characteristics;

- Query vendors by a parameter or specified set of parameters and/or capabilities. (GTSS Report, 6 August 1997, 1)

GTSS enables supplier capabilities to be "matched" with product characteristics across any number of data fields. This streamlines the bid process by enabling buyers to determine, prior to solicitation, which manufacturers are capable of making the desired component.

Technologies such as GTSS can help with the task of grouping parts according to physical characteristics and help identify electronically capable SMEs for the On-Demand Manufacturing (ODM) and Virtual Parts Supply Base (VPSB) initiatives.

### 3. Standard for the Exchange of Product Model Data (STEP)

STEP is an international standard for the computer-interpretable representation and exchange of product data (Honeker, 1997; SCRA, 1997). STEP provides a visual, graphic, 3-D representation of product information along with mechanisms and definitions to enable product data to be exchanged. Exchange of a product's technical data takes place during the entire product life-cycle, including design, manufacture, operation, maintenance, and disposal. (RAMP, 1997)

### *a. STEP and Life-cycle Savings*

RAMP is one of the technological programs that promotes and employs STEP and its many Application Protocols.[8] In the following quotation, the "RAMP Team" summarizes its views on how STEP can assist in life-cycle data requirements:

> The overall objective of STEP is to provide a mechanism that is capable of describing product data throughout the life cycle of a product, independent from any particular system. The nature of this system makes it suitable not only for neutral file exchange, but also as a basis for implementing and sharing product data bases and archiving. The ultimate goal is [to enable] an integrated product information database that is accessible and useful to all the resources necessary to support a product over its lifecycle. (RAMP, 1997)

While this objective does not address remanufacturing for legacy weapon systems, technical data for a spare part can be both created and stored in STEP format. For parts which are expected to require subsequent reprocurements, creation of STEP data allows rapid issue of complete and accurate technical data to the assigned supplier. (RAMP, 1997)

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[8] The two Applications Protocols (APs) used for Small Mechanical Parts (SMP) are AP203 (Configuration-controlled Design) and its successor, AP224 (Mechanical Products Definition for Process Planning Using Machining Features) (SCRA, 1996). SCRA leads a for-profit international consortium (PDES, Inc.) consisting of over 20 major corporations and Government organizations dedicated to accelerating the development and adoption of these and other STEP Application Protocols.

### *b. Demonstrated Benefits of STEP*

The RAMP Team conducted several pilot projects which attempted to validate the utility of both RAMP technology and STEP. Participants were both large and small manufacturing companies. This sub-section presents and explains feedback from these companies.

Unless digital product data files are transferred from buyer to supplier on congruent CAD systems, product data must be manually translated into the supplier's CAD system. Since product modeling data are used to derive CNC machine code, errors associated with manual data entry result in delays in production lead time (PLT). One participant calculates that "each occurrence of a conventional part modeling error costs between four and five hours of production time." (Texas Instruments Report, 21 November 1996, 2) These errors are "normally directly attributable to the [in]accuracy of the modeling data...from which the NC program code was developed." (Focus: HOPE, 31 July 1997, 7) Additional comments from participants are listed below:

> The STEP file eliminates the first part of the NC Programming process: creating an electronic model of the part. The translation of the STEP data into the CAM system was flawless in every case, without a single glitch, error message, or mistake in part geometry. (Campbell Engineering Report, 16 May 1997, 2)

> The use of validated AP203 STEP files [which] were 100% accurate in developing NC program code results in decreased production errors..., virtually eliminating the need to return [NC] programs from the Manufacturing Floor to Engineering for correction after the production job is scheduled and all necessary preparations are complete. This will drive down production and ultimately procurement costs. (Focus: HOPE, 31 July 1997, 9)

> [T]he highly accurate and complete STEP part information that was electronically transmitted via the Internet [provided] a level of confidence not usually found when programming a part. This...means...time saved in our company in Quality Control (QC) and [less] down time for the machines. (CNC Industries Report, 16 May 1997, 9)

> Based on experience gained from this project, Dynetics personnel feel that both the RAMP and STEP...technologies appear to be ready for increased exposure and implementation into the small to medium manufacturing communities. (Dynetics Report, 16 May 1997, 10)

These comments from the various pilot projects provide evidence that STEP can streamline manufacturing processes. STEP eliminated delays caused by programming errors; STEP helped alleviate concerns with Quality Control (QC); and, STEP increased machine operating time. This feedback supports the RAMP Team's contention that STEP is an important asset for DOD-sponsored FCIM initiatives like the Virtual Parts Supply Base (VPSB) and On-Demand Manufacturing (ODM). (Team SCRA Report, 1997)

## C. SUMMARY

Parts One and Two of this chapter present a sample of existing organizations and technologies which can help

resolve the problem of a lack of legacy weapon system spare parts. Table 2 summarizes these programs.

| *Education and Networking Outreach Programs* | | |
|---|---|---|
| Program | Sponsor | Traits |
| Electronic Commerce Resource Centers (ECRC) | DOD | Educates firms about EC, EDI, TDI through free seminars; promotes DOD initiatives |
| Oak Ridge Centers for Manufacturing Technology (ORCMT) | DOE | Teams with CIS in providing technology outreach for CIS-networked firms |
| Robert C. Byrd Institute (RCBI) | DOD DARPA | Teaches machining skills; unites small firms into a competitive DOD supplier |
| *Technologies* | | |
| Name | Sponsor | Attributes |
| Rapid Acquisition of Manufactured Parts (RAMP) | NAVSUP | Supports just-in-time manufacturing of difficult spare parts |
| Group Technology Selection System (GTSS) | RAMP | Enables the capture of NSN codes and vendor capability; streamlines bid process |
| Standard for the Exchange of Product Model Data (STEP) | PDES, Inc., et. al. | Provides accurate, CAD-neutral digital data for manufacturing processes; |

Table 2: Summary of Outreach Programs and Technologies (Table Created by the Author)

Together, these implementation programs and technologies are positioned to help find solutions to spare part reprocurement problems. However, there are barriers which impede the success of the programs and technologies. The issues are presented and discussed in Chapter IV.

# IV. IMPLEMENTATION ISSUES

In spite of outreach programs like those discussed in Chapter III, barriers related to digital product data and supplier willingness to participate as a DOD contractor remain. This chapter presents a set of the issues that may inhibit DOD's partnering with SMEs to "rapidly supply DOD with unique, cost-effective spare parts in limited quantities to maintain legacy weapon systems." (ODM Workshop, 1996) One or more of the following issues could impede the successful implementation of both ODM and VPSB.

## A. GOVERNMENT AS A CUSTOMER

The business community's perceptions of the Government as a customer may influence the decision to become a supplier. Competing for the same small-sized manufacturing capacity as other industries, DOD can benefit from taking stock of its performance as a business customer.

### 1. Economic Conditions

The author conducted research for this thesis during a period (July to December, 1997) characterized by a strong U.S. economy. A study by Liao and Greer (1983) connected contractors' active participation in DOD markets with less than favorable economic conditions. Conversely, the study suggests that a favorable economy creates more opportunity for small businesses, and leads to apathy toward Government contracts. As one industry official remarked, "Small businesses today can afford to ask themselves, 'How can I make the most money with the least bother.'" (Interview-B,

1997) Supported by a favorable economy and able to choose their clients, small manufacturers do not have to tolerate extra labor which may accompany Government contracts. This "extra labor" is discussed in the following section.

### 2. Numerous Competitors

Aspects of the Group Technology Selection System (GTSS) or equivalent may intimidate large or small suppliers. Recall that GTSS is a database of manufacturers' capabilities and spare part characteristics. GTSS could potentially place a large number (e.g., 30) of small manufacturers into competition (RAMP, 1997). Three of the manufacturers interviewed foresaw not taking the time to attempt to win a contract when competing against dozens of other firms. With the odds of winning the contract reduced, machine shop owners see those bid efforts as an inefficient use of time. (Parks, 1997; Interview-C, 1997; Campbell, 1997)

### 3. Extra Certification, Testing, and Administration

"Government contracts are inches thick and full of all kinds of certification." (Gentsch-A, 1997) Whether fact or exaggeration, the perception has the potential to foster the belief that the Government is an undesirable business customer.

One issue is that some DOD spare parts require unnecessary tests and certification processes. While it is true that certain weapon systems demand traceability to the lowest level of sub-contractor, not all parts within the system should. According to one Government-certified manufacturer,

> I shouldn't have to send a doorknob...away for strength-testing, but since it's going on an airplane and is coded as such, I send it to testing. (Interview-C, 1997)

Note the comment that the doorknob was "sent" for testing. Small shops typically do not have the capability to certify heat-treatment, conduct magnetic inspection, or perform non-destructive or ultrasonic testing. (Interview-C, 1997)

These actions require the small shop to outsource selected activities and processes, adding time and labor to the contract, turning "a five-dollar part into a 25-dollar part." (Interview-C, 1997) Unnecessary certification and testing efforts tax the machine shop with extra requirements such as special certification paperwork and Government-prescribed packaging (Interview-C, 1997).

**4. Small Lot Sizes**

Generally, manufacturers do not stand to generate much profit from the small-quantity contracts at issue (Grisar-A, 1997; Ryburn, 1997; Interview-A, 1997). Manufacturers must order raw materials, design the product, tool up machines, test and ship each production lot. These activities require efforts which are "other-than-manufacturing" and keep employees away from production processes. Generally, longer production runs are more profitable (Gentsch-B, 1997).

Additionally, small lots of challenging, unique spare parts could require the personal attention of senior shop personnel and take other workers away from regular production functions (Interview-C, 1997).

### 5. Past Working Relationships

Several interviews revealed that manufacturers' working relationships with their regular customers are invaluable to their respective businesses. The interviewees expressed "human factors" as being very important, as the following two examples illustrate.

One manufacturer has a strong business partnership with "Company Z" in making precision mechanical parts. "I can call [Company Z] and tell them that we're slow; they help by sending me jobs ahead of schedule." (Interview-C, 1997) In this scenario, Company Z has a vested interest in helping the manufacturer since he has a history of making high quality parts for them.

Another machine shop owner says, "When [my employees] work late to ship a part to a customer overnight, I get a fax or telephone call from the other end." (Interview-A, 1997) The acknowledgment from a long-time client gives this owner a feeling of gratification for his hard work, as he knows the client appreciates the extra effort. This manufacturer of precision components for NASA's Space Shuttles added, "With the Government, it's always somebody different; they are like a faceless customer to me." (Interview-A, 1997) Although the manufacturer supplies parts to NASA, he stated a preference for dealing with private sector organizations with which he could maintain a more personal business relationship. (Interview-A, 1997)

In addition to the quality of the relationship influencing the suppliers, other shops do not show interest in doing business with the Government at all due to past performance of the Government. Instances of the Government backing out of a contract (Honeker, 1997) or not providing

promised business (Gentsch-A, 1997) can permanently alienate firms from dealing with the Government. Failures like these are likely to upset any manufacturer, and decrease their willingness to do business with such a customer.

## B. THE GOVERNMENT'S FIRST ARTICLE TESTING PARADIGM

The Functional Economic Analysis of On-Demand Manufacturing (Gentsch, 1997) identifies two issues which could limit lead time reduction. One issue is selection of NSNs, which is covered in the next section of this chapter. The other issue is the first article inspection (test):

> First-article inspection is an independent quality-control review of the first item produced in a production run...[and]...is imposed by the part's user (the military service's engineering authority) on parts that are highly critical to mission performance or human survival. (Gentsch, 1997, 7-5)

For cases in which there is competition for a particular SMP, "each and every manufacturer needs to pass the first article test, which is both expensive and time consuming." (Elliot, 1996, 3) While some small machine shops can perform the tests, highly specialized shops generally have to outsource such testing (Interview-C, 1997). The Functional Economic Analysis of ODM points out that third-party first article testing "jeopardizes the quick-response nature of On-Demand Manufacturing." (Gentsch, 1997, 7-5)

## C. DATA-RELATED ISSUES

Even assuming successful formation of the supply bases sought by the On-Demand Manufacturing (ODM) and Virtual Parts Supply Base (VPSB) initiatives, problems remain

regarding the ability to transfer a part's complete and accurate technical data.

### 1. Unavailable, Incomplete, Unreadable, or Obsolete

When a staff member of the Oak Ridge Centers for Manufacturing Technology (ORCMT) toured selected Small- and Medium-sized Enterprises (SMEs), he learned of severe data problems during the tour, stating:

> During these visits we were told that it is common for the small suppliers to find that prints and specifications are not available when they request them for preparing quotes. (Douglass, 1997)

Even if data are available, manufacturers frequently encounter difficulty with technical data that are "often incomplete, unreadable, or obsolete." (Gentsch, 1997, 7-5)

### 2. NSN Selection Economics

The Logistics Management Institute (LMI) acknowledged the problem of selecting which parts would need to be remanufactured. It is a challenge to anticipate which parts will encounter demand:

> Because the vast number of national stock numbers (NSNs) with little demand, it seems uneconomic to review and revise the technical data in advance of a part requirement. Much effort would be expended on parts that may never experience demand. (Gentsch, 1997, 7-5)

Without advanced review there is little guarantee that the complete technical data will be available when needed.

### 3. Use of Electronic Data Formats

Electronically capable machine shops are transferring product data files using the Initial Graphics Exchange Standard, IGES (pronounced *eye-jiss*).[9] Although this thesis presents evidence suggesting that STEP is superior to IGES, it should be understood that DOD essentially does not have a large inventory of electronically formatted drawings. For the vast majority of legacy system parts, DOD continues to be incapable of rapidly disseminating product data in computer-interpretable formats to remanufacturing contractors. As commander of the Defense Supply Center Columbus (DSCC), Rear Admiral Ernest A. Elliot observed,

> [W]e haven't yet embraced the concept [of] manufacturing from STEP, IGES, or any other electronic files. In fact, we are struggling mightily with how to accept a digitized data technical package in lieu of [paper] drawings. (Elliot, 1996, 3)

## D. "JEDMICS"

One DOD asset which would have to "embrace the concept" of electronic data files is the Joint Engineering Data Management and Information Control System (JEDMICS). Every Government source in this thesis mentioned JEDMICS as a critical element in Department of Defense FCIM applications. JEDMICS is a technical data repository which is "the

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[9] Designed to be an "initial" standard, IGES is a graphics exchange standard that provides the ability to electronically transfer a graphic representation of a component between CAD systems. Skilled CAD/CAM programmers generate tool paths for the CNC machine by translating the images in the IGES picture into CNC machine code.

approved joint service system for storage, management and retrieval of engineering data" (OSD-CALS, 1997, 3.3.1). Storing and cataloguing of advanced Technical Data Packages (TDP), such as STEP files, is expected to become part of DOD's operations. OSD-CALS' VPSB Concept Paper lists JEDMICS as one existing resource to be used in actuating virtual enterprises. (OSD-CALS, 1997, 3.3.1). Additionally, DOD acquisition regulations (DOD Regulation 5000.2-R) direct that

> Beginning in FY97, all new contracts shall require on-line access to, or delivery of, their programmatic and technical data in digital form," [unless it is deemed cost-prohibitive to do so.] (DOD Regulation 5000.2-R, 1996, 3.3.4.5)

Technical Data Packages (TDPs) housed at JEDMICS need to be accessible to suppliers wishing to participate in the DOD supplier market. At the same time, JEDMICS must deal with issues of confidentiality with respect to certain systems and therefore keep access restricted. Currently, even military Inventory Control Point (ICP) personnel are restricted in accessing JEDMICS' library of aperture cards, microfiche, and drawings (Dowell, 1997).

## E. SEARCHING FOR SOURCES

Bid opportunities (i.e., Request For Quote (RFQ)) are made available to contractors through various media, including electronic bulletin boards on the Internet. For the parts considered in this thesis, it is during this period that administrative lead time (ALT) delays manifest themselves. Recall that the procurement portion of administrative lead time (ALT) consists of bid solicitation,

the wait for contractors' responses, source selection, and contract award. Procurement accounts for 58 percent of ALT (Figure 3). An LMI sample of 1,529 parts revealed ALT to average about 96 days, with most contracts awarded between 30 and 250 days. (Gentsch, 1997, iv) These data suggest that difficult parts can remain on an electronic billboard for months without attracting a single qualified response.

An interview with one small manufacturer indicates a reason why these data are not surprising. Given a small machine shop that does a low percentage (10 to 15 percent) of its business in government contracts, it is not very attentive to Government demand (Interview-C, 1997). The small shop owner generally cannot afford to pay an in-house employee to monitor commerce media full-time. So, unless the shop owner chooses to pay someone (i.e., a broker) to monitor commerce bulletin boards for him, small manufacturers may overlook Government bid opportunities.

The apparent passiveness toward Government business opportunities may also reflect the effect of a strong economy.

## F. SMALL MANUFACTURERS' PERCEPTION OF STEP

The RAMP Team's *STEP-Driven Manufacturing at Small and Medium Manufacturers Pilot Project* succeeded in achieving their objective, which was "to demonstrate and document the case for successfully employing STEP-based technology" in SMEs (Team SCRA Report, 1997, Cover). The author agrees with the project's label as a success. Yet, as this section points out, more evidence is needed to convincingly document the potential advantages of STEP.

### 1. Simplicity of Parts

Feedback provided in Chapter III pointed out the attributes of STEP data. Yet, the parts selected for the project were all made from aluminum and were not complex:

> Overall, the parts selected for fabrication during this project were of very simple to average complexity. In the majority of cases, it would have been much quicker to have allowed an experienced, skilled machinist to fabricate the parts manually. (Dynetics Report, 16 May 1997, 10)

A similar STEP pilot project involving Texas Instruments reveals a desire to explore STEP's abilities on more complex mechanical parts using "exotic or non-traditional machining processes" (Texas Instruments Report, 21 November 1996, 6):

> Although the parts selected were generally of moderate complexity representing a cross-section of practical defense parts, a higher level of complexity and variety...would have been ideal. (Texas Instruments Report, 21 November 1996, 7)

As a result, the Pilot Project provides little evidence that STEP data can be used to manufacture parts with complex geometries.

### 2. No Savings For Simple Parts

There is also testimony that STEP does not yield savings when manufacturing simple parts. One participant in the Pilot Project concluded that while the three-dimensional model available with STEP saves the CAD programmer time usually spent creating that model,

> The amount of time saved varies with the complexity of the part. For very simple parts, using a STEP file actually adds time to the process. The break even point seems to be those parts which take about thirty minutes to model in the CAD system. (Campbell Engineering Report, 16 May 1997, 6)

Campbell's point was that skilled CNC machine operators can make some simple parts more quickly than can the CAD/CAM system.

Overall, the evidence presented in this section reveals that there is a level of complexity for which STEP has been proven to provide savings. However, Small- and Medium-sized Enterprises (SMEs) may be unwilling to invest time and money in STEP unless they know there is a market for that format — both with DOD and in the private sector (O'Neill, 1997). The Program Director for a RAMP-capable machine shop stated that changes in technology will not happen in some small manufacturing companies until it is no longer economically feasible to stay in business using non-electronic business exchange media (O'Neill, 1997).

## G. SUMMARY

This chapter has presented a set of issues which may adversely affect the implementation of DOD reprocurement programs. They include the Government's relationships with its suppliers, first article testing requirements, product data format issues, data repository issues, source selection delays, and small manufacturers' perceptions of STEP. Some of the issues were drawn from individual interviews with Government and small business representatives, while others were presented in technical reports or Internet sites.

# V. ANALYSIS OF IMPLEMENTATION ISSUES

## A. DISCUSSION AND ANALYSIS

Chapter IV presented implementation issues that could impede DOD's plans to establish a responsive base of small manufacturers to assist with legacy system spare part procurement. The following discussion focuses on those issues and recommends changes in some existing DOD efforts which include using additional DOD efforts to promote the participation of small manufacturers.

### 1. Single Process Initiative

Promulgated on 8 December 1995, (Perry, 1995) the Single Process Initiative (SPI) is a DOD mechanism "to modify the specifications and standards for all existing contracts on a facility-wide basis." (Kaminski, 1996, 4) SPI accepts case studies from manufacturers who find themselves being required to adhere to "different, even inferior processes" (Kaminski, 1996, 2) called out by a Government contract. DOD action teams then modify such aspects (e.g., specifications, test requirements) of the existing contracts with a goal of "consolidat[ing] or eliminat[ing] multiple management or manufacturing processes." (Kaminski, 1996, 2)

If utilized by small manufacturers, SPI is positioned to streamline administrative or manufacturing requirements placed on DOD contractors by eliminating paperwork associated with redundant testing, certification and

packaging. This should free the small manufacturer to concentrate on manufacturing.

Research on the cost-savings resulting from past contracts revised by the Single Process Initiative would provide a useful business case which could help advertise the program and solicit more suggestions from industry.

### 2. First Article Testing

First article tests certify that the first unit of a lot complies with design specifications. Whatever the answer to time delays associated with first article testing, there cannot be any retreat from rigid standards which certify mission critical parts and personnel safety:

> Clearly, part quality and reliability cannot be sacrificed in order to attain quick delivery; however, an alternative to the lengthy delays imposed by first-article inspection should be addressed. (Gentsch, 1997, 7-5)

Employing certified digital data files can potentially eliminate some first article tests. Rear Admiral Elliot remarked,

> Today, we use a first article test to prove that a certain facility can produce an item. But, if an electronic description of a widget exists, any [Government-certified] manufacturing facility that is capable of processing the electronic data is capable of producing an acceptable part without the time and expense of a first article [test]. (Elliot, 1996, 3)

In other words, use of a 100-percent accurate electronic file by a Government-certified supplier can eliminate the need for first article tests in some areas.

### 3. JEDMICS

Given DOD's involvement with technology initiatives that promote exchange of product technical data, DOD should ensure that JEDMICS can securely interact with private defense manufacturers to receive, store, retrieve, catalog, and disseminate data filesets in electronic formats. A technologically-oriented research effort could help identify the obstacles which may inhibit development of JEDMICS' interface capability.

### 4. NSN Identification Alternative

One alternative to selecting individually from the millions of DLA-controlled parts (Chapter IV) is to aggressively pursue procurement of spare parts for a specific platform, such as those shown in Figure 1. One system-specific effort that is prolonging the lifetime of KC-135 tanker aircraft is the Aircraft Structures Procurement program.[10] The KC-135 case represents a victory in mobilizing Government and industry manufacturing assets to solve a major reprocurement dilemma. (Grisar-B, 1997; ASP, 1997)

A valuable first step in research pertaining to Aircraft Structures Procurement (ASP) would be to "Interview

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[10] The KC-135 tanker aircraft is an in-flight refueling platform. Without the KC-135, flight ranges of tactical air assets are reduced to a one-time fuel payload. The Aircraft Structures Procurement program is supported by OSD-CALS through VPSB (Grisar-C, 1997). ASP seeks to "identify and leverage sources of supply for aircraft structures and components" (ASP, 1997, 3) by integrating "the skills, capital, human resources and commitment to deliver a weapon system service life extension solution." (ASP, 1997, 1)

industrial manufacturers and organic government depot personnel to determine the manufacturing opportunities and issues for each identified aircraft structure." (ASP, 1997, 3)

### 5. The STEP File as an Independent Cost Variable

As described in Chapter III, STEP files can be used throughout the life-cycle and can reduce the need for a reserve inventory, or safety stock (Honeker, 1997). Perhaps the possibility of using STEP files as an independent cost variable in DOD source selection processes for future procurements should be considered.

The DOD manual for acquisition requirements states that for all new system procurements, "The [Program Manager] shall provide for long-term access to data required for competitive sourcing of systems support." (DOD Regulation 5000.2-R, 1996, 3.3.7) Similarly, Program Managers of legacy weapon systems should consider the inclusion of compatible electronic data (e.g., a STEP file) upon delivery as an additional "feature" of the part. Special consideration should be given to cases where DOD pays "extra" for a component which comes with a STEP file. However, the Government taking custody of technical data created by CAD/CAM efforts at the SME level needs to be carefully considered. Interestingly, even though the Government has had rights to the technical data in the majority of Campbell Engineering's contracts, Campbell stated that the Government "generally has not wanted the electronic stuff." (Campbell, 1997)

If the Government begins using STEP files as an independent cost variable, how will businesses react to

Government taking custody of the technical data? Regarding more complex parts, manufacturers may deem their electronic data as proprietary (Honeker, 1997; Carter, 1994).

### 6. Implementation of STEP by Industry

Electronically capable machine shops are slowly discovering STEP, as the following comment from the Dynetics Report illustrates:

> The introduction of the STEP technology to Dynetics can certainly be viewed as a success. Prior to this [pilot] project STEP was nothing more than another acronym in the realm of graphics translation. (Dynetics Report, 16 May 1997, 10)

STEP has the technological attributes and sufficient industry support to serve as the file transfer standard for digital product data in the 21st Century. But, one RAMP-capable shop director points out that STEP's widespread use by small businesses is predicated on the leadership from large industry. As big industries adopt STEP standards and demand that sub-tier suppliers conform, software companies will placate the demand and make STEP more widely available through commercially-available CAD software (O'Neill, 1997). One STEP official indicated that some CAD software firms already have STEP applications ready for mass distribution, but are waiting for sufficient growth of the market for STEP (Interview-B, 1997). For example, major corporations such as Boeing and Ford Motor Company have found STEP to be very useful in their engineering functions (RAMP, 1997). In fact, as one STEP advocate has observed, those corporations do not wish to reveal to their competitors the savings brought on by the efficiencies of STEP (Interview-B, 1997).

A strong business case illustrating the use of STEP by these businesses could provide much-needed support for STEP's percolation into mainstream manufacturing aggregate. DOD should support follow-on efforts by STEP-related activities such as the RAMP Program to build on previous pilot projects and develop its own business case.

### 7. Right-sizing of Supplier Pools

The National Aeronautics and Space Administration (NASA) has found success in reducing administrative lead time of spare parts procurement through an innovative contracting arrangement which both minimizes the number and assures the qualifications of its suppliers. Campbell provided the following account of NASA's process:

> NASA's procurement process used to be horrible. Now they evaluate their good suppliers up front. They [NASA] identified a given need for random machined parts over a period of five years. Today, after a screening and selection process, NASA's pool of suppliers consists of five qualified companies who compete for each of NASA's spare parts jobs. Having qualified the suppliers, all NASA does is compare prices and award a contract. (Campbell, 1997)

By comparison, the Model Contract for On-Demand Manufacturing does not indicate the presence of competition among a small set of chosen suppliers (LMI, 1997). If the Defense Logistics Agency (DLA) does not obtain multiple sources for ODM contracts, DOD places itself in danger of losing its sole source of supply. The author recommends that DLA consider the NASA example and evaluate using multiple (at least two) qualified sources for each ODM contract.

## B. ADDITIONAL FUTURE STUDY

Although these topics are not part of the study, they surfaced as tangential issues during the research.

### 1. Insufficient Internet Bandwidth

Use of the Internet as a transfer medium for digital product data could afford Technical Data Package (TDP) access to any potential DOD supplier. If this is done, small businesses will become especially reliant on the Internet for information transfer as Electronic Commerce evolves. (Klein, 1997; ECRC, 1997) One issue which impedes use of the Internet is its bandwidth of roughly 40 kilobytes per second (Kbps). Some technical drawings can be hundreds of megabytes, therefore it is not feasible to send a procurement package containing tens of drawings over the Internet (Klein, 1997). Research to resolve the issue of limited Internet bandwidth should look at emerging technologies which facilitate more expeditious file transfer rates.

### 2. Microelectronics Spare Parts

VPSB intends to form virtual enterprises for all classes of DOD spare parts, but the "Initial VPSB Focus Area" is microelectronics. (Ryburn, 1997; OSD-CALS, 1997, 6.2) That pool of parts involves different considerations than those used for mechanical parts. For example, rapidly changing information systems technologies can dramatically shorten the effective lifetime of electronic components.

With such short-lived effectiveness, how can DOD acquire cost-effective microelectronics spares which will

also last a sufficient amount of time? In considering new acquisitions, what considerations should Program Managers give to the longevity of the microelectronics components within their systems? Research of these and related topics could be valuable to OSD-CALS' microelectronics effort.

# VI. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

## A. SUMMARY

This thesis analyzes selected DOD reprocurement initiatives for securing responsive manufacturing capacity of small manufacturing companies to overcome problems of spare parts procurement for legacy weapon systems. Interviews with Government and industry representatives and managers of small manufacturing shops identified possible barriers to the application of the DOD initiatives. Barriers were analyzed and recommendations given for building a flexible, computer-integrated manufacturing supply chain between the Department of Defense and small manufacturers.

## B. CONCLUSION

Given the budgetary restraints which DOD must accept, life-extension of legacy systems will continue until modernization via new weapon systems is economically viable. The following excerpt from a 1996 Logistics Management Institute report identifies some root causes of problems with the reprocurement of legacy weapon system spare parts:

> DOD sometimes finds itself with no (or incomplete) technical data and no contractor support. This can occur because
>
> - ...the cost of acquiring a full technical data package is considered too high; [see Honeker, 1997]
>
> - the life-cycle support contractor fails or becomes extremely expensive;

- unanticipated replacement of parts is required, such as when a part's service life extends well beyond what was planned during the initial design, procurement, and provisioning. (Gentsch, et. al., 1996, 3-8)

This thesis finds the DOD initiatives, On-Demand Manufacturing (ODM) and the Virtual Parts Supply Base (VPSB), to be well-designed and achievable programs to overcome the problem of obtaining legacy weapon system spare parts. However, there are obstacles identified in this thesis to successful implementation of the programs.

## C. RECOMMENDATIONS

The analysis in Chapter V identified specific actions to take to overcome the obstacles to the successful implementation of the ODM and VPSB programs. The actions are captured in the following recommendations:

- DOD should utilize technologies (such as Electronic Commerce, RAMP, and STEP) and initiatives (such as the Single Process Initiative) to reduce inefficiencies throughout its manufacturing and business processes.

- DOD should provide the means to successfully create, store, and distribute accurate Technical Data Packages (TDP) in electronic formats so that DOD suppliers can improve their manufacturing productivity.

- DOD-sponsored outreach efforts toward SMEs should continue to prepare small manufacturers to work with DOD using modern industrial technologies so that the country's small manufacturers will be ready to provide invaluable support to programs that help sustain legacy weapon systems.

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   Department of Systems Management
   Naval Postgraduate School
   Monterey, CA 93943-5000

6. LT Brett E. Fillmore.....1
   Cromwell Hall, SOAC 09802
   New London Submarine Base
   Groton, CT, 09034

7. Mr. Jason Hirsh.....1
   RAMP Program Manager
   Naval Supply Systems Command
   Suite 501
   1745 Jefferson Davis Highway
   Arlington, VA 22202

8. Mr. Alexander Johnston IV.....1
   PRC, Inc.
   2611 Jefferson Davis Highway
   Suite 8000
   Arlington, VA 22202-4029

9. Mr. Eric L. Gentsch.....1
Research Fellow, Logistics Management Institute
2000 Corporate Ridge
McLean, VA 22102-7805

10. Mr. Glenn O. Ryburn.....1
Program Manager, Virtual Parts Supply Base
5203 Leesburg Pike
Suite 1609
Falls Church, VA 22041-3401

11. Dr. John H. Bradham.....1
Vice President
South Carolina Research Authority
5300 International Boulevard
North Charleston, SC 29418